

# Health-effects on cows that have lost their calves to predators in Brazil



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## Hälsoeffekterna på kor som har förlorat sina kalvar till rovdjur i Brasilien

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## SUMMARY

In my bachelor thesis, I wrote about direct damage after predatory attacks on cattle. The conclusion from this thesis was that secondary effects of the attacks are more difficult to assess and compensate economically. According to animal owners I met it is also a problem that the cattle are stressed after an attack and their health is affected. This study therefore aims to see if it is possible to assess how the cattle's health is affected after a predatory attack. The goal is to identify protocols that can be used, and which health indicators are worth studying for this purpose. In addition, to see if there is any indication that health is affected as a result of predatory attacks. Brazil and the Fazenda Real São Bento farm were used for study as the conflict between predators and cattle is extra clear and present there. Before the trip and the practical study began, various welfare protocols were studied. A protocol from the AssureWel-project was used as a basis for the study, with some minor changes. The animals included in the study were mainly cows postpartum, but also others in mixed phases of lactation and gestation. Cows that lost calves to predators during the past year were then compared with other cows to assess whether the health status was different between the two groups. Parameters assessed were BCS (Body Condition Score), MBS (Maternal Behaviour Score), swellings, lesions, lameness, cleanliness, respiratory disease and "other diseases".

The study showed no clear evidence that the health status of cows who lost calves to predators would have a decreased level of health than other cows. However, the number of cows who lost calves in the past year is not sufficient for major conclusions to be drawn from the results. Therefore, cowboys were trained on the farm in order to score the body condition and mother's behaviour on the cows to gain a greater number of observations to draw conclusions from. The protocol used worked well and the study itself was practical and feasible. However, many questions remain on the subject. For example, what factors contribute to the chance that a calf will be attacked, how much are the animals stressed by predator attacks compared to other stressors and how long the stress affects the animals, etc. Therefore, more studies are needed in this area.

## **SAMMANFATTNING**

Mitt kandidatarbete handlade om direkta skador efter rovdjursattacker på boskap. Slutsatsen därifrån var att sekundära effekter av attackerna är svårare att bedöma och ersätta, samt enligt många djurägare även värre att leva med. Denna studie syftar därför till att se om det går att bedöma hur hälsan påverkas sekundärt efter en rovdjurattack. Målet är både att komma fram till vilken typ av protokoll som kan användas och vilka hälsoindikatorer som är värda att studera i detta syfte. Dessutom att se ifall det finns något som indikerar att hälsan påverkas till följd av rovdjursattacker. Brasilien och farmen Fazenda Real São Bento användes för försöken, då konflikten mellan predatorer och boskap är extra tydlig och närvarande där. Innan resan och den praktiska studien påbörjades studerades olika välfärdsprotokoll och ett protokoll från AssureWel-projektet användes som bas för studien, med vissa mindre förändringar. De djur som bedömdes var kor framförallt postpartum men även under blandade stadier av laktation och dräktighet. Kor som förlorat kalvar till rovdjur under det senaste året jämfördes sedan med övriga kor för att bedöma om hälsoläget såg annorlunda ut mellan de två grupperna. Parametrar som undersöktes var kroppskondition, moderns beteende, svullnader, skador, hälta, renlighet, respiratoriska sjukdomar och ”övriga sjukdomar”.

Studien visade inte några tydliga tecken på att hälsoläget hos kor som förlorat kalvar till predatorer skulle ha ett sämre hälsoläge än övriga kor. Dock var antalet kor som förlorat kalvar det senaste året inte tillräckligt stort för att några större slutsatser skulle kunna dras från resultaten. Därför tränades cowboys på gården för att kunna poängsätta kroppskondition och beteende på korna för att få ett större antal observationer att dra slutsatser ifrån. Det använda protokollet fungerade bra att använda och själva studien var praktisk att genomföra. Dock kvarstår många frågor angående t.ex. vilka faktorer som bidrar till chansen att en kalv kommer att bli attackerad, hur mycket djuren stressas av rovdjurnärvaro jämfört med andra stressorer och hur länge stressen påverkar djuren m.m. Därför behövs mer studier på området.

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## INTRODUCTION

The idea for this thesis originates from my bachelor thesis in which I wrote about injuries and effects of predatory attacks on livestock. One of the conclusions I drew from this work was that secondary effects of predatory stress are both harder to measure and compensate economically than direct injuries from predatory attacks. Many farmers and animal owners that I met expressed that stress from fear of a possible attack is almost worse than the attack itself. As I understood, this is because the fear is constant and gives the farmers a sense of hopelessness. Furthermore, they expressed that the animals that have survived a predator attack also seemed to be affected a long time afterward though this was hard to prove or prevent. During my bachelor thesis, I found it hard to find articles and research in the area of secondary effects of predator attacks. Therefore, I now take the opportunity and highlight this topic in my master thesis. The reason why I choose to travel to Brazil for this study is because the farmer-predator conflict is far greater and up close than in Sweden. There are a couple of issues that I would like to address in this thesis:

- Is it at all possible in a standardized manner to measure health effects of predatory stress?
- If so what parameters are easiest and best to look at?
- Are there any parameters that seem to affect to what extent the cows lose their calves to predators?
- Finally, does predatory stress affect the health and behavior of cattle and to what extent?

The objective of this thesis is to design a protocol that measures to what extent the health and welfare of cattle is affected by predator attacks and predatory presence. The purpose of this is both to show the farmers/ranchers that we understand their point of view in this conflict, as well as laying the foundation for something that in the future hopefully could be used in determining what economical compensation should be given after predator attacks. This in turn could help us preserve our large predators.

## **LITERATURE REVIEW:**

### **Brazil and livestock husbandry:**

Brazil is the world's 5<sup>th</sup> largest country both in terms of area and population (IBGE, 2017). It's the seventh largest economy by GDP and as a member of the BRICS group it has in modern history been one of the world's fastest growing economies (IMF, 2017). In 2016 this country was the world's largest beef exporter and second largest beef producer after the United States of America (MAPA, 2017).

Historically the beef production has been located to the more industrialized areas in southern Brazil, but has in recent years expanded more and more to the central-western and northern territories (Kumm & Larsson, 2007). Still about 70% of the production takes place in the southern areas and on the cerrado (north-western savannah biome). This biome covers over 20% of Brazil's surface area and is an ecosystem rich in biodiversity. However today about 50% of this biome is under human use and 35% of the original area covered by these savannahs has been converted into pastures and crops (Marquis & Oliveira, 2012).

According to Kumm & Larsson (2007) increased yield per hectare has meant production growth in the country, but it is still low in comparison to for example Sweden. Causes for the low production per hectare in the country are that pastures are poor regarding nutrients, long dry-seasons and warm/moist climate in the Amazon etc. All of these factors contribute to low fertility and high slaughtering age. Another factor that's important for the beef production is that the used Zebu cattle breeds normally have low slaughtering weights, and the production is based exclusively on grazing without additional concentrates (Kumm & Larsson, 2007).

### **Nelore Cattle:**

The most common species of domestic cattle in Brazil is called Zebu (*Bos indicus*) and 90% of these animals comprises of the breed Nelore (OSU, 2017). They originate from India and have many differences from European cattle, from which they are considered to be a different subspecies. Their most eye-catching characteristics are the hump behind their neck and their loose white skin. This skin combined with a low level of metabolism contributes to great heat resistance. The Nelore cattle's biggest advantage in tropic climate is their hardiness. They feed frequently but lightly and can withstand long periods of drought. Furthermore, the breed has low ratio of dystocia, alert calves and highly developed maternal instinct (OSU, 2017).

### **Pantanal region:**

The Pantanal is the world's largest wetland stretching from Mato Grosso and Mato Grosso do Sul in Brazil and over the borders to Paraguay and Bolivia. It is an area covering 210 000 km<sup>2</sup> with vast fresh-water reservoirs (WWF Brazil, 2015). During the rainy season (December and January) 80% of the Pantanal is flooded and due to this the soil is relatively fertile. All these factors have attracted farmers since the 18<sup>th</sup> century and cattle ranching is the main economic activity in the region. With increasing economic competition in the beef production farmers have been forced to increase the number of animals per hectare in a sensitive ecosystem with a

rich biodiversity. In the Pantanal, there is a huge number of species of plants, birds, fish and large mammals including predators (WWF Brazil, 2015).

### **Predator-cattle conflict:**

Jaguars (*Panthera onca*) are on top of the food-chain in Brazil and the predator which are responsible for most of the cattle kills in the Pantanal area. In many cultures, these animals are considered symbols of power and beauty, while in some areas they are considered to be a problem. According to Cavalcanti (2008) only 46% of their historical range is today occupied by jaguars. The habitat loss has led to increased coexistence and conflicts between jaguars, farmers and cattle. A study of 10 jaguars in the Pantanal area between the years of 2001-2004 concluded that their kills were mainly composed of 31.7% cattle, 24.4 caimans (*Caimaninae*) and 21% peccaries (*Tayassuidae*). The cattle kill rate varied seasonally with the rainfall as the main factor. During the rainy season the number of caiman kills increased due to rising water levels and therefore more availability. Conversely during the dry season cattle were moved further from the farms to reach new pastures and therefore cattle kill rates increased (Cavalcanti *et al.*, 2010).

Crawshaw *et al.* (2008) investigated the conflict between jaguars, pumas (*Puma concolor*) and cattle in central-western Brazil during the years 1998-2003. Their study showed that predator attacks contributed to 18.9% of the total cattle mortality, which represents about 0.3% of the cattle stock value in economic loss. Calves and especially new-born calves were targeted more frequently, while attacks on calves older than 8 months was practically absent. 59.2% of the predator-killed animals were males. Other studies like the ones by Schaller (1983) and Polisar *et al.* (2003) showed lower mortality results with depredation contributing to between 10-13% of the total cattle mortality.

The extent of the conflict between jaguars and cattle ranchers has also been studied by way of looking at the ranchers' attitudes towards these animals. In a questionnaire-study conducted by Zimmerman *et al.* (2005) fifty respondents answered with these agreement rates:

- We would like to receive help at this ranch with solving the depredation issue – 94%
- This ranch has suffered cattle losses to jaguars – 82%
- Predation on cattle is a problem that the local authorities should address more – 80%
- This ranch cannot tolerate jaguars taking any cattle – 64%
- Jaguars deserve protection – 74%
- The nature/wildlife of this area is a national treasure – 100%

Hunting jaguars is forbidden in Brazil since 1967 where they are seen as a threatened species, even though internationally they are classified as near threatened by IUCN. However, the persecution of these animals continues mostly because of the perceived threat to livestock and

people. The species also faces a major threat in form of habitat loss due to the human population growth and expansion (Cavalcanti *et al.*, 2010).

### **Animal welfare:**

Before we can try to assess and measure how the cattle's welfare is effected after a predator attack, we have to define animal welfare.

### **Definition of animal welfare:**

Animal welfare is something that has interested people through all times and was earlier defined as absence of pain, diseases and injury as well as treatment of these. The last two decades have seen a steady increase of research in this area (Appleby *et al.*, 2011). One of the most well-known and recent definitions was made by the World Organization of Animal Health (OIE) in 2012 which defines animal welfare as follows:

“Animal welfare is how an animal is coping with the conditions in which it lives. An animal is in a good state of welfare if it is healthy, comfortable, well nourished, safe, able to express innate behavior and not suffering from pain, fear or distress.”

This definition focuses on the animal's perception of its surroundings as well as its feelings. Measuring factors that effect this welfare can generally be divided into either looking at the animal's environment and management procedures on the ranch or looking at the animal itself. This is called using resource-, management- or animal-based measurements (EFSA, 2012).

### **Different welfare measurements:**

Assessing animal welfare by looking at resources and management is also called risk assessment. This is because those measurements often find potential risks that might affect animal welfare (EFSA, 2012). Parameters studied with risk assessment can for example be housing, bedding material, feeding of the animals, analgesics used in castration and breeding policies etc. These parameters are often easy to measure, objective and do not change over time so therefore they are usually used in regulations and lawmaking. The downside is that they don't consider the animals perception of its surroundings and therefore don't actually measure animal welfare according to OIE's definition (EFSA, 2012).

Animal based measures on the other hand take into account both reactions and effects on the animal itself. This kind of measurements are therefore called outcome-based measurements and can be studied both directly by looking at an animal or by looking at records of for example growth rates (EFSA, 2009). As the parameters studied are more subjective and might change over time it's important to choose parameters that are valid, repeatable and feasible. It is also important that they are studied by a person with sufficient knowledge in the area and preferably someone who assesses welfare regularly. An explanation of the different types of measurements can be found in figure 1 (EFSA, 2009).

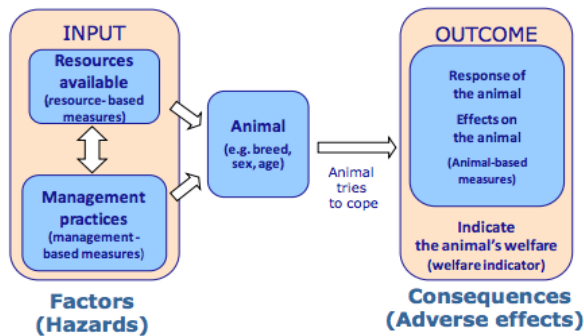


Figure 1. *Explanation of animal-, resource- and management-based measures.* EFSA, 2009.

### ***Designing a welfare protocol:***

When designing a welfare protocol, it is necessary to choose between risk based- or outcome-based measurements/parameters. EFSA has expressed that both risk reduction and assessment of outcome are necessary to ensure good welfare (EFSA, 2012). The Welfare Quality® project, which is a project funded by the European Union to elaborate a standardized protocol for assessing animal welfare, focuses more on animal-based measures (WelfareQuality®, 2009a). According to this project more and more welfare research focuses on the animal's feelings instead of the risk assessment which historically has been considered easier to process.

Algers & Smulders (2009) debate that some risk-based measures could actually stop some welfare problems from ever occurring. Additionally, some animal-based parameters are very complex and dependent on many factors which makes them hard to predict and assess. This limit the use of animal-based measurements both economically and practically for routine inspection. According to EFSA (2009) it is also important to consider that for different parameters risk/cause and outcome/problem might differ in time. For example, lack of water gives a quick response from the animals, but problem with housing or flooring might take some time to discover when looking at animal-based measures (EFSA, 2009).

### ***Choosing welfare parameters:***

Winckler (2008) contemplates, as also stated earlier in this thesis, that the three most important features of a good welfare parameter are:

- Validity – accurate and precise in describing animal welfare
- Repeatable – as objective and reproducible as possible
- Feasible – economical, practical and time effective etc.

He then continues to conclude that parameters can be divided into behavioral, physiological and pathological parameters. The physiological parameters though are in cattle welfare assessment often not available due to feasibility reasons. Here are some welfare parameters found in multiple welfare protocols and why they are relevant:

*Body condition* – Body conditions score is a way of measuring the animal's fat reserves. This can be used to find a balance between economical feeding and good productivity as well as assessing animal welfare. Even though cows can differ a great lot depending on their lactation, they should never be scored as excessively thin or overweight (AssureWel, 2017). Cattle that aren't getting their nutritional demands met can suffer from hunger, health problems, reduced fertility and having slow growing calves. On the other hand, overweight cattle have an increased risk of dystocia, lameness and reduced fertility. It is important to adapt the scores depending on cattle breed and country (AssureWel, 2017). A study by Edmonson *et al.* (1989) found that assessing the pelvic and tail-head areas were the areas that gave the least amount of assessor subjectivity.

*Lameness/Mobility* – Lameness in animals is associated with discomfort and pain. Additionally, it predisposes them to further disease e.g. swollen hooks, mastitis as well as reduced fertility and weigh gain. Usually lameness in cattle is caused by foot lesions which can be both infectious or non-infectious. Early detection and treatment can significantly limit welfare problems and minimize complications (AssureWel, 2017). As a detailed examination of the claws is not achievable in routine herd welfare assessment, many different mobility/lameness scoring systems has been developed. These scoring systems shows high correlations to claw lesions and tries to minimize variations between observers (Archer *et al.*, 2010).

*Cleanliness* – Fregonesi *et al.* (2007) investigated cleanliness assessment and cows lying-behavior and found that they always prefer to lie dry and clean surfaces. Dirty animals indicate welfare problems that can be related to management issues or unhealthy animals. Dirt can irritate the skin, increase infection risk and give ectoparasites ideal conditions for survival (AssureWel, 2017).

*Lesions and swellings* – Even though minor skin lesions/swellings are inevitable in larger herds; major or multiple lesions/swellings indicate skin damage for some reason. These lesions can originate from poor management/surroundings, cattle interactions, ectoparasites or other injuries. Swellings can in addition be an abscess or a cyst. Recording of location and size of the lesions are crucial for determining their cause (AssureWel, 2017).

*Animal-human response* – The cattle's relationship to humans has been shown to have significant impact on welfare, health and production. This can be assessed by avoidance distance tests in cattle that are free ranging. However, these tests usually require a large sample size and therefore aren't very feasible (Winckler, 2008).

*Respiratory signs (coughing, nasal discharge, hampered respiration)* – Diseases in the respiratory tract are common (especially in young, housed beef cattle) and might even be life threatening. It is used as a welfare measurement as it is unpleasant for the animals and decreases weight gain while it decreases economical profit due to medical treatment etc. (AssureWel, 2017).

*Others/Animals in need of care* – This is an essential welfare parameter as animals who are sick/injured and not receiving proper care might suffer from pain and distress. Not only the sick

animal's welfare is effected but this can also decrease recovery, production and increase risk of the disease spreading (AssureWel, 2017).

*Calf survivability* – Lombard *et al.* (2007) concludes that stillborn calves and culled heifers contribute to a great economical loss as well as it can suggest low animal welfare. Simple interventions can decrease herd level of dystocia and the number of assisted calving.

*Casualty/Mortality* – Mortality rates are both associated with animal welfare and economical profits of farmers. Dividing the records after age groups can facilitate the detection of underlying causes (AssureWel, 2017).

### ***Different welfare protocols:***

Sejian *et al.* (2011) claims that there isn't one established welfare protocol that is usable in every situation, but that it is possible to use existing protocols as guidelines and design your own. They also write about veterinarians using welfare protocols and conclude that veterinarians are experts at assessing animal health and disease severity. But assessing welfare differs from that as disease severity measures are based on a small number of physical parameters with established normal ranges. Welfare on the other hand are based on a broad range of multifaceted parameters. Therefore, veterinarians often fail to include these measurements (Sejian *et al.*, 2011).

Between the years of 2004-2009 the EU founded a project called Welfare Quality®. The objective was to increase animal welfare in the food producing chain, as costumer awareness and market demand for good food quality grows. The project established 12 different criteria on which they based their welfare protocol (tab. 1).

Table 1. *Criteria for animal welfare according to Welfare Quality®, 2009b*

<b>Welfare principles</b>	<b>Welfare criteria</b>
Good feeding	Absence of prolonged hunger Absence of prolonged thirst
Good housing	Comfort around resting Thermal comfort Ease of movement
Good health	Absence of injuries Absence of disease Absence of pain induced by management procedures
Appropriate behaviour	Expression of social behaviours Expression of other behaviours Good human-animal relationship Positive emotional state

The Welfare Quality® protocol focuses mainly on animal-based measurements.

Swedish veterinarian students also practice welfare measuring using protocols from the company Växa Sweden. They have different services which focuses on improving animal health and thereby profits of the farm. Examples are:

*Ask the cow:* Where trained welfare assessors regularly visit to give the farmer a better view of the farms strengths and weaknesses. The assessors look at parameters that can improve animal welfare as well as profits.

*Health package:* A full service in the animal health department where veterinarians, counselors and farmer works together for a period of time to improve animal health and economical profits. The service includes welfare assessment, statistics and action planning etc.

Another welfare protocol was developed between 2010-2016 in a project called AssureWel which was created by RSPCA, Soil Association and Bristol University. The aim of this project was also to create a practical and easy to use welfare assessment protocol which can be found in Appendix A.

### **Effects of predator-attacks:**

There are many examples of studies which show that predator presence or threat leads to a huge release of stress-related hormones. For example, Campos *et al.* (2012) showed that predator exposure gave mice long-lasting anxiogenic effects associated with hyper activation of amygdaloidal complex related to symptoms of post-traumatic stress disorder (PTSD). PTSD is a chronic condition of alterations in emotional and physiological health, which can follow a traumatic experience. Examples of these health alterations can be anxiety, depression and nervous behavior (Campos *et al.*, 2012).

### **Stress:**

Stress is a term with many definitions but Breazile (1988) describes it as “an internal (physiologic or psychogenic) or environmental stimulus that initiates as adaptive change or a stress response in an animal”. Jensen (1996) calls it an umbrella term for responses to threatening situations and that these responses can be both positive and negative for the animal.

Möstl *et al.* (2002) writes that the main hormone triggered by stress in animals is cortisol and other glucocorticoids. When the animal is stressed the hypothalamus stimulates the anterior pituitary to release adrenocorticotrophic hormone (ACTH). This triggers the adrenal glands to release glucocorticoids to increase gluconeogenesis and inhibit inflammatory reactions etc. These physiological responses serve to prepare the animal for fight or flight. There are many ways to collect samples and measure cortisol in wild or semi-wild animals. Sheriff *et al.* (2011) claims that the main techniques utilized are blood, saliva, excreta (urine/feces) and hair. All the mentioned sampling methods have advantages and disadvantages of their own.

### **Stress-related sickness and disease**

It is a well-known fact that acute negative stress can cause health problems and stress related disease (Breazile, 1988). Stress can lead to poor blood circulation, hypothermia and ischemia. This in turn can lower the cells metabolism and cause cell death, which in worst-case scenario



gives grave dehydration and even death through cardiac arrest. Some more usual disorders caused by stress are stomach ulcers, vomiting and chock. Predatory stress can also have a negative impact on the cattle's health by making them change their feeding patterns and social patterns (Kreeger *et al.*, 2002).

There is also a condition related to the hunting and capturing of animals called Capture Myopathy. This is caused by prolonged or particularly strenuous and stressful captures of an animal and can lead to ataxia, weakness, myoglobinuria (dark/brownish urine) or even death. Kreeger *et al.* (2002) writes that the full pathogenesis of this disease is not fully understood yet, and that animals don't have to show signs of Capture Myopathy straight away but that these symptoms can arise several days after the capture.

There are also many studies and experiments that conclude that stress during pregnancy can have a negative effect on the embryo. For example, Manning & Stamp Dawkins (1998) found that the mother physiological state is directly related to the well-being of the embryo. This means that increased stress of the pregnant female can have a negative effect on the embryo itself and therefore also on the reproduction.

## **MATERIAL AND METHODS**

### **The farm and daily schedule:**

The study was carried out on a farm in southern Pantanal in Mato Grosso do Sul. The farm is called Fazenda Real São Bento and has about 3500 cattle in total, including calves. The farm works with several different livestock breeds such as Nelore, Pantanal cattle, Angus and Buffalos. However, the largest proportion of animals is Nelore. The cattle are raised as free-ranging and grazing animals until they are about 18 months old, when they are sold to other farms. Some animals are kept for further breeding. At around 23 months of age the Nelore are inseminated and thereby giving birth 9 months later. Following the birth, calves are caught for ear-marking, vaccination and disinfection of the umbilical cord. No birth-weight is recorded but weaning-weight is. The farm of 9200 hectares is divided by fences into 50 paddocks and between some of these there is a small area where calves can be caught and handled. There is also one bigger corral on the farm where treatment of sick animals is possible, but unusual according to the managers.

The farm has some predation problems as about 40 cattle each year are killed by mainly jaguars but also a few pumas. In addition, there are also several attacks without fatality. Most of the attacked animals were calves and young cattle. Cows which have their offspring taken by predators are kept and inseminated again. Animals who lose their calves due to for example reduced fertility or poor mother properties are sent to slaughter. Another study was executed at the farm at the same time as this one which focused at trying to map where and how the attacks takes place.

Collection of data was done during two weeks between the 16/10-29/10 of 2017. This is the end of the dry season in the Pantanal as described in the literature review. Assessing animal welfare is limited by the fact that the cattle of São Bento are free-ranging and therefore difficult

to handle. At the same time identification of the animal-ID needs the assessor to be close enough to see the earmarking of the cow. Therefore, the assessment was done during calf-handling in the morning between approximately 8-10.30 a.m. every day. Three cowboys rode out every morning at 7 a.m. and gathered all animals from the paddock where gestational cows are kept. The handling paddock is divided into two areas. After a calf was caught with lasso, it was then dragged into the other area through a gate, with the cow following its calf. During the catching and dragging phase maternal behavior was assessed. Then the calf was taken into a small handling booth and earmarking, vaccination and disinfection of the umbilical cord was performed. During this period, with the cow at close range, the other parameters were assessed from all angles and then recorded in the protocol. The calf was then released back to its mother.

In the afternoon, some days were spent assessing cows from the horseback, while helping the cowboys gather the animals. This assessment was done in three different paddocks with calves at varying ages and cows at different stages of gestation. The cattle in each paddock were assembled and cowboys kept them still while the assessor rode in at closer range to be able to see the ID-number and assess as many cattle as possible.

### **Welfare protocol:**

As stated earlier in this thesis there is no one correct or best welfare protocol for every situation, but instead you need to assess your objectives, assets and limitations and choose the protocol and parameters you think will serve you best.

The objective of this study was to create a protocol with health parameters to assess the effects of predatory stress on cattle in Brazil. Therefore, only animal-based measures should be used as these assess the outcome of predatory stress instead of risk factors. Even though these parameters also could be used to determine if they are risk factors or not.

It was possible to assess welfare on a large number of animals as well as getting production data from the farm. The morning routine with calf handling was a perfect opportunity to assess the cows as we here could study maternal behavior and look at them at close range. The farmers' managers also showed interest in continuing collecting BCS and maternal behavior data and supply us with this information.

The protocol needed to be relatively easy and quick to use. As the cows were not tame or kept in an enclosure no hands-on assessment was possible. The cows were free-ranging and kept outside for all year around. Furthermore, only natural drinking water was supplied and considering all these factors no protocol which includes management- and resource-based measurements could be used.

As further stated in the literature review there was mainly three different protocols assessed in this study. They were all read thoroughly, and one protocol chosen as the foundation for which parameters to assess. This protocol can be found in appendix A. One day was spent on the farm preparing and evaluating the parameters before the real assessment started. During this day and throughout the whole process BCS and maternal behavior score was compared with 3 other assessors to see that the necessary reliability was reached. Also 2 evenings were spend training

the cowboys with videos and pictures of maternal behavior and BCS so that they could also continue using this method.

AssureWel was the protocol used as foundation for the study. This is because it is easy to use and has good descriptions of how to score the animals. Furthermore its only based on animal-based measurements that can be observed from a distance. The protocol is divided into two parts but only the first part which focuses on the animals was used. The only parameters added to the protocol was the ID-number of the calf and a maternity behavior score, which will be described later in this chapter. Both these parameters were only recorded during calf handling in the mornings and not when assessing animals from the horseback. The statistic parts of this protocol were not included in daily assessment, but statistics were later received via mail.

Welfare Quality<sup>®</sup> and Health package were read and evaluated before the practical study started but were not used due to a couple of reasons. The Welfare Quality<sup>®</sup>-protocol is very detailed and contains many different parameters. It is also well described how the scores should be compared and statistically analyzed to assess the farms general animal welfare. Why it was not used for this study is because many of the parameters are resource-based and therefore not relevant (example water provision, management of castration/dehorning and access to pasture etc.). Furthermore, some parameters that was important in this study like BCS only had two scores (0 or 2), while AssureWel uses a 9-point scoring system for this parameter.

Health package by Växa Sweden is also based on animal-based parameters and very easy to use. The reason why this protocol was neglected in favor of AssureWel's protocol is due to the fact that it's more adapted to Swedish lactating cow and their conditions. For example, parameters used are number of cows laying down, rising behavior and claw health.

### **Choosing animals to assess:**

During the calf handling in the mornings every calf that had been born the past day or during the night was caught, and the mother to this animal was assessed. This was done with the exception of other breeds than Nelore. They were not included in the study, but during my two weeks on the farm only three cows that had given birth was another breed then Nelore. Every morning between 10-20 animals were assessed.

During the afternoons spent assessing animals from the horseback animals were chosen at random. Every cow that could be assessed and ID-number controlled was also included in the study. Only standing animals were assessed and animals laying down were first forced to stand up before assessment. Only Nelore cattle were included in the study. The fact that the same cow could be assessed many times as the cattle moved during assessment was not seen as a problem, as this can be used to evaluate the reliability of the method.

### **Parameters and assessment:**

This is a description of the parameters that were assessed. Cows were as far as possible assessed from all sides and while moving. The AssureWel-protocol were used to record data directly after every animal had been assessed. During the second week, also the cowboys were given

paper and pencil to see if they could assess the parameters in a reliable way. Except for the parameters that are described below also cow number, calf number and date were noted.

### **Body Condition Score:**

Body condition was scored with scores ranging from 1-5 with possibility to score half point in case the cow was in between two scores. Main areas on the cow for evaluating BCS is the tail-head and loin.

*1 (Extremely thin)* - Animal on the brink of starvation. Tail-head with deep cavities, no fat tissue and very prominent pin bones (tuber ischii). Spine prominent and every vertebra can be identified individually. This also applies to the horizontal processes which has sharp edges. Also hook bone (tuber coxae) and thurl (hip-joint) is prominent and with no fatty tissue. No fat covering the ribs and shelf-like appearance between vertebra and horizontal process. Rumen usually completely empty.

*2 (Thin)* - Thin animal with about the same traits as for cows in BCS 1, but the difference is that there is some fat tissue in generally all the areas. Shallow cavities next to the tail-head and prominent pin bone, but some fat tissue under the skin. Spine and horizontal processes individually identifiable but more round ends than in BCS 1. Shelf like appearance of the loin and some fat padding over the hook bone and over the ribs.

*3 (Moderate)* - Good/moderate amount of fat tissue. This is the score which should be pursued. Tail-head with barely any cavities and pin bone visible but not prominent. Loin area is flat and while vertebrae and processes can be seen they are not individually discernible. Barely visible ribs and hook bone.

*4 (Fat)* - Excessive amount of fat tissue. Filled tail-head and rounded appearance of the loin area. No visible horizontal processes and rounded hook- and pin bones. Ribs covered by fat and thurl is filled.

*5 (Extremely fat)* - Obese animal with flat appearance and bone structures buried in fat. Tail-head with fat patches and completely rounded loin. Back is solid without visible horizontal processes. Hook-, pin bones and ribs with obvious fat padding. Filled thurl and the cow has generally a thick layer of fat.

*0,5-scores* - In case a cow was assessed to be in between two scores there was possible to score the cow with a 0.5 score for example 2.5 or 3.5.

*Example of scores:*



2



2.5



3



3.5

Photographer: John Greve. Taken at Fazenda Real São Bento.

### **Maternal Behaviour Score:**

This score is a type of animal-human response parameter which were proposed to use in the study by our colleagues at UNESP, the University of Sao Paulo State. They had developed the score based on how cowboys in Brazil catch and handle the calves. The scoring begins as the cowboy on horse approaches the cow and her calf, continues as they calf is caught by lasso and dragged into the second area and ends as the calf is inside the small handling area in the middle of the paddock. 7 different scores were possible:

1 - Looking from a distance. A cow that keeps it distance and doesn't go over to the second area (through the gates). Still she is constantly watching her calf and may try to communicate verbally.

2 - Showing love and following the calf. This is a cow who stays close to her calf and follows it all the way when it has been caught. Even if she sometimes stops it still counts as a score 2 if the cowboys can manage her to follow the calf through the gate.

3 - Aggression towards the cowboy. A cow which shows aggression or tries to defend her calf without charging. For example, stomping the ground or doing fake charge movement without actually getting closer to the cowboy.

4 - Attack towards the cowboy. A full attack or charge towards the cowboy puts the cow in score number 4.

5 - Ignoring the calf. This is a cow that completely ignores her calf when it is captured. Looking in another direction and pretending like nothing special is going on.

6 - Trying to escape or run away. A cow which tries to run away and escape the paddock when the cowboy approaches her or when her calf is caught.

7 - Abandoned calf. A calf without a mother that can be identified.

### ***Lameness:***

Lameness was recorded as described by the AssureWel guidance of the assessment protocol. Only difference was that the group 0/1 was divided into two groups. This gave the following scoring:

0 - Good mobility with even weight bearing, rhythm, long fluid strides and flat back.

1 - Uneven weight bearing, rhythm or shortened strides but with no immediate limb that can be identified as the problem-limb.

2 - Impaired mobility due to uneven weight bearing or shortened stride on a limb that can easily be identified.

3 - Same signs as in score 2 but the cow is unable to walk as fast as a brisk human pace and cannot keep up with the herd.

### ***Cleanliness:***

Cows were assessed as the AssureWel guidance proposes. Only the hind quarter was included in the judgement (from the front edge of the udder and back down to the coronary band of the hind legs). Score 0/1 was divided into two separate scores.

0 - Clean cows with no dirt.

1 - Minor splashing and staining to the coat.

2 - Dirty cows with areas of dirtiness (fresh or old/dried) amounting to at least 40 cm (a forearm) in any direction.

### ***Lesions:***

As much as could be seen of the animals were observed for signs of skin damage like wounds, scab or scars. Only lesions with a diameter over 2 cm were recorded. Cow number and location of the lesion was written down.

### ***Swellings:***

Same assessment as for the lesions but swellings (abnormal enlargement extending out from the body) needed to be at least 5 cm in diameter to be counted.

### ***Respiratory symptoms:***

The animals were observed for signs of respiratory disease. Coughing, nasal/ocular discharge and labored breathing was noted.

### ***Others/animals in need of further care:***

There was also space in the protocol for assessment of other signs of decreased welfare and health. Especially animals not receiving the appropriate care should be noted in this parameter.

### **Compilation of data and results:**

During the days on the farm the data was recorded on paper using a pencil and every night this data collection was transferred in to an Excel file. Paper copies was kept as an insurance. Results were later redesigned into diagrams using Microsoft Office Excel 365 and evaluated using the same program.

## **RESULTS**

### **Overview of assessment and farm statistics**

In total 270 welfare assessments were made regarding 240 animals (meaning that 30 of the assessments were duplicates). Whereof 104 cattle were evaluated during the calf handling routine postpartum, and these were included in the scoring of maternal behavior. Results from all the welfare indicators assessed will be presented in this chapter.

Statistics of calf mortality were sent via mail from the farm. They also provided statistics of BCS and maternal score of cows that had given birth in October/November. See table 2 and 3 for the calf mortality last year (01/07/2016-30/06/2017) at Fazenda Real Sao Bento:

Table 2. *Mortality of calves with earmarking. Statistics from Fazenda Real Sao Bento between 01/07/2016-30/06/2017. Calves killed by jaguars and pumas have been marked in red.*

Cause of death	Female	Male	Total	%
Slaughter	2	0	2	3
Accident	2	0	2	3
Jaguar/Puma	22	22	44	75
Snake	5	3	8	14
Unknown	2	1	3	5
Total	33	26	59	100

Table 3. *Mortality of calves without earmarking. Statistics from Fazenda Real Sao Bento between 01/07/2016-30/06/2017. Calves killed by jaguars and pumas have been marked in red.*

Cause of death	Female	Male	Total	%
Unknown	12	10	22	41
Accident	0	2	2	4
Jaguar/Puma	5	16	21	40
Snake	0	1	1	2
Vulture	0	1	1	2
Dystocia	0	1	1	2
Disease	3	2	5	9
Total	20	33	53	100

As can be seen above the two major causes of death is jaguar attacks and unknown causes. The latter is when no clear underlying reason was found. Noticeable in young calves (calves without earmarking) is also that more male calves are attacked by jaguars. In the older calves the jaguar attacks are relatively an even bigger problem.

### Body Condition Score

All the assessed cows were evaluated regarding their BCS. As far as possible they were assessed from both sides and from behind. Due to the fact that the cattle weren't tame some of the evaluations from horseback had to be done merely from one side and from behind. All throughout the process, evaluation of the reliability of the scoring system was done by comparing and discussing scores.

Below in figure 3 scoring provided by the farm is shown. This scoring was made by the cowboys trained during my time at the farm. In the scores supplied by the farm the majority of the cows were scored as 2.5 (72%). There were also two cows scored as a 1 and one cow scored as a 4.5.

Of the assessed cattle in the study conducted by me (see figure 2), none were found to be extremely thin (1 or 1.5) or fat (4 – 5). 16 of the cows were thin and 77 of them (32%) were scored between thin and moderate. The largest proportion of animals was considered to have good fat deposits (110=46%) while 37 were scored slightly above normal.



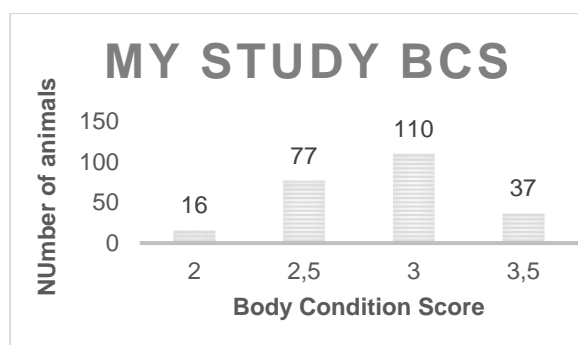


Figure 2. BCS of cows scored by me between 19/10-27/10 of 2017. Scores ranging from 1-5 but only groups where cows have been scored are shown. The Y-axis shows number of cows scored in that group.

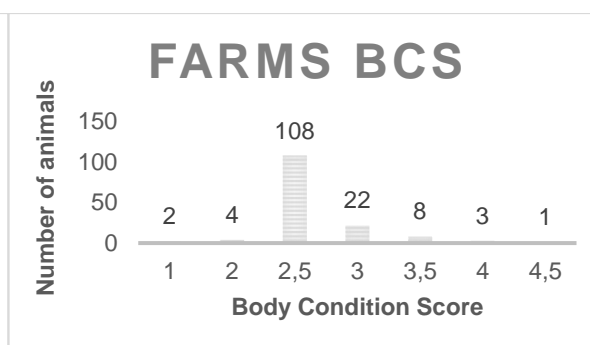


Figure 3. BCS of cows scored by the cowboys between 28/10-15/11 of 2017. Scores ranging from 1-5 but only groups where cows have been scored are shown. The Y-axis shows number of cows scored in that group.

Below the study conducted by me has been split up into the group of cows that were evaluated postpartum (see figure 4) and the rest of the cows (see figure 5) that were scored in varying stages of lactation and gestation. A difference can be seen with the mean score of 2.63 postpartum but the same score is 3.02 for the rest of the cows.

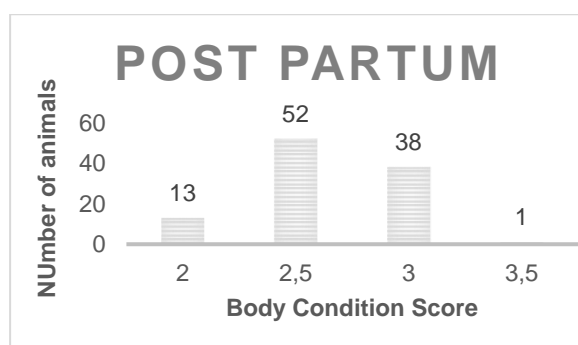


Figure 4. BCS of cows scored by me postpartum during calf handling. Scores ranging from 1-5 but only groups where cows have been scored are shown. The Y-axis shows number of cows scored in that group.

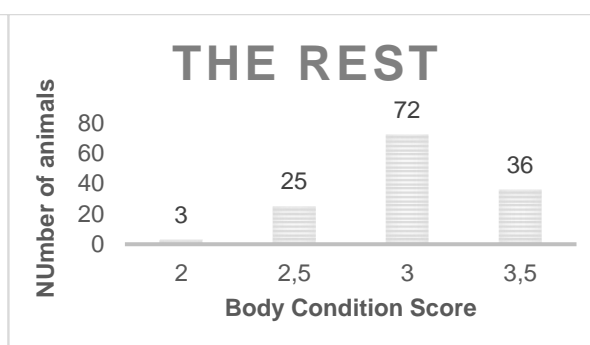


Figure 5. BCS of cows scored from horseback. These cows were in varying stages of lactation and gestation. Scores ranging from 1-5 but only groups where cows have been scored are shown.

Reliability was evaluated by looking at scoring of duplicates. Of the 30 animals scored multiple times 3 (10%) were scored with different scores at different occasions. All these wrong assessments were made between scores 3 and 3.5. When including these scores in the statistics the score made during the calf handling was chosen as the most trustworthy as more time was spent looking at each cow at that time.

Statistics obtained later from the farm showed that 10 of the animals assessed in the study had lost calves to jaguars within the last year. These scores can be seen in figure 7. Below there is also a diagram summarizing the scores in the study conducted by me and the scores provided later by the farm (see figure 6).

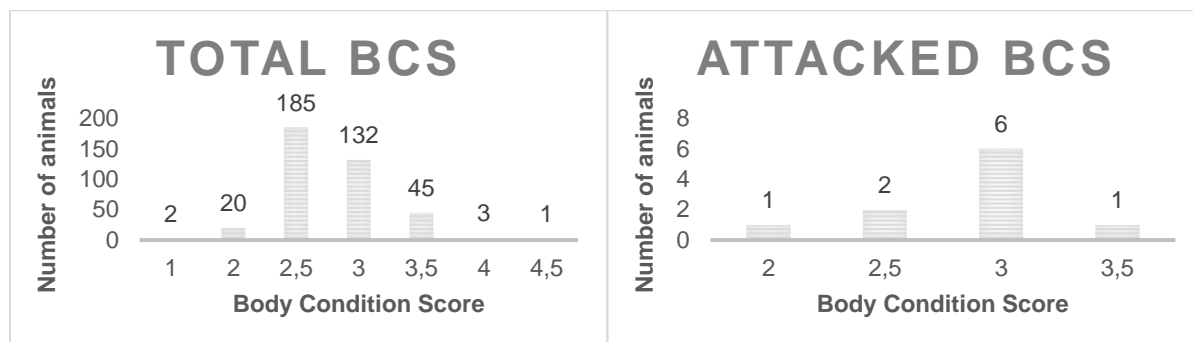


Figure 6. BCS of all scored cows between the period 19/10-15/11 of 2017. Scores ranging from 1-5 but only groups where cows have been scored are shown. The Y-axis shows number of cows scored in that group.

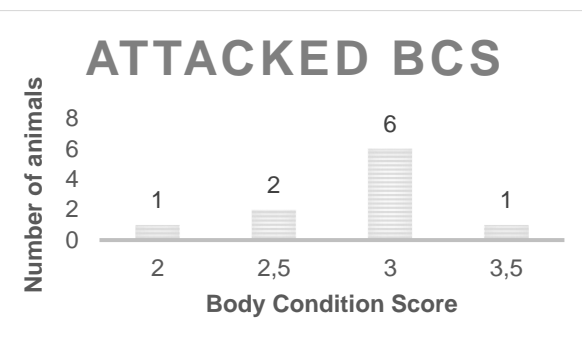


Figure 7. BCS of all scored cows that have lost calves to predators within the last year. Scores ranging from 1-5 but only groups where cows have been scored are shown.

### Maternal Behaviour Score

As stated earlier only the cows assessed during calf handling could be assessed using this welfare indicator. My scoring can be seen in figure 8, and the farm supplied data from calf handlings from October/November which has been added in figure 9. It is clear the vast majority of cows have been scored in group 2 (85% in total). Also noticeable is that none of the cows were scored in groups 5 or 6, while 4 calves were found abandoned.

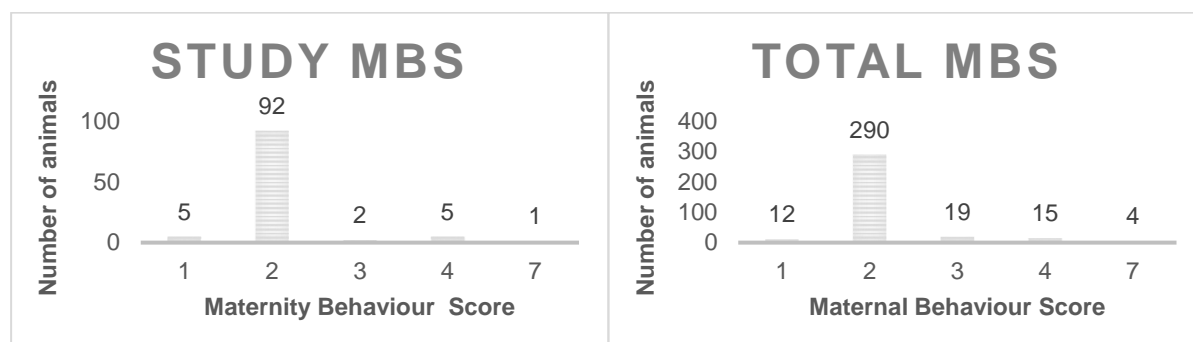


Figure 8. MBS of cows scored by me between the 19/10-27/10 of 2017. Scores ranging from 1-7 but only groups where cows have been scored are shown. Explanation of the scores can be found in materials & methods. The Y-axis shows number of cows scored in that group.

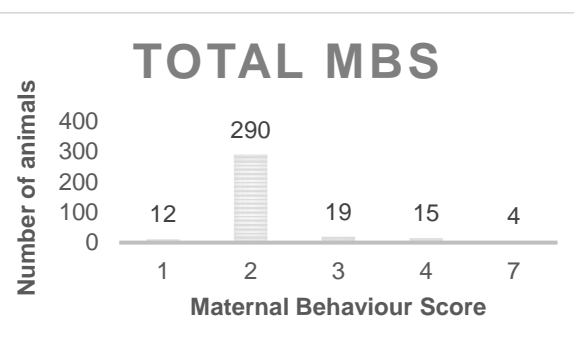


Figure 9. MBS of all cows scored by me and the cowboys between the 19/10-15/11 of 2017. Scores ranging from 1-7 but only groups where cows have been scored are shown. Explanation of the scores can be found in materials & methods.

Eight of the cows who had lost calves to jaguars within the last year was assessed based on this parameter. 7 of them was scored as group 2. This is the group were cows are loving and follows the calf without showing aggression towards the cowboys. The last cow was scored as a cow which fully commits to attack the cowboys. Scores of cows that had lost calves to predators are shown in figure 10.

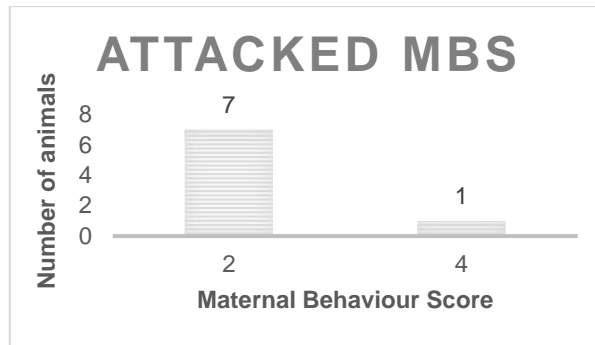


Figure 10. *MBS of all scored cows that have lost calves to predators within the last year. Scores ranging from 1-7 but only groups where cows have been scored are shown. Explanation of the scores can be found in materials & methods. The Y-axis shows number of cows scored in that group.*

## Swellings

Out of the 240 animals included in the study 19 were found to have swellings larger than 5 cm in diameter (see figure 11). Of these 16 were placed on the neck approximately on the vaccine injection site. One of the cow with a swelling on one of the back legs was not noted during evaluation from the horseback while the swelling was noted during calf handling. None of the three cows who had lost calves to jaguars had any swellings.

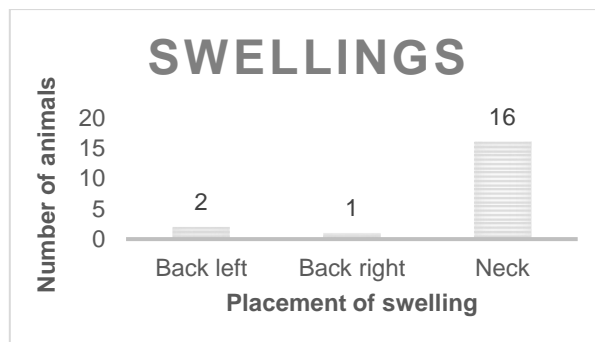


Figure 11. *Swellings larger than 5 cm in diameter and their location. This parameter was recorded during 19/10-27/10 of 2017 on a total of 240 cows.*

## Lesions

Lesions with diameter over 2 cm were noted in 6 of the 240 animals included in the study (see figure 12). Examples of lesion recorded is for example one cow which had lost an ear and one with a large scar on a back leg. None of the cows which had lost a calf to predators recently had any obvious scars or lesions.

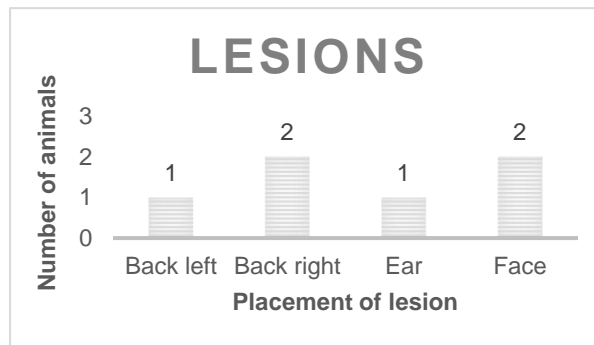


Figure 12. *Lesions larger than 2 cm in diameter and their location. Parameter recorded on 240 cows during 19/10-27/10 of 2017 at Fazenda Real Sao Bento.*

### Lameness, Respiratory disease, Cleanliness

These welfare indicators have been bundled together because not so many animals were found to have these indicators of impaired health (see figure 13). Two animals were lame whereof one was mildly lame and the other had impaired mobility (score 2). One cow was recoded to have a cough. 7 of the 240 cattle included in this study were assessed to have minor splashing to the coat while one cow was scored as dirty. None of the cows which had lost calves to jaguars had a problem with any of these health parameters.

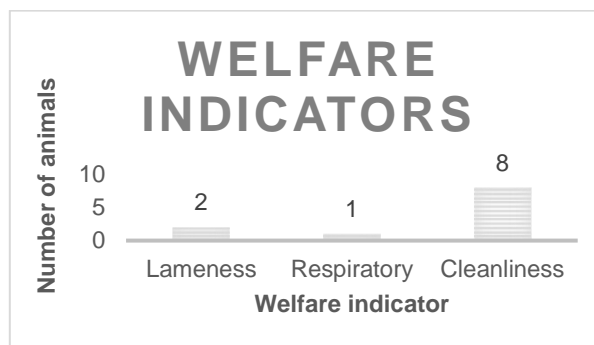


Figure 13. *Number of recordings of lameness, respiratory disease and cleanliness at the farm Fazenda Real Sao Bento between the 19/10-27/10 of 2017.*

### Other diseases or health problems

Generally, the cattle on the farm gave a healthy impression. Three of the cows that had recently given birth was noted to have one teat and part of the udder which was definitely larger than the other ones, but no further examination was done. Also, one calf had worms in the umbilical cord.

## DISCUSSION

### Overview of purpose and questions at issue

The main objective of this thesis was to examine the possibility of assessing secondary effects of predatory stress. Both to see what parameters are best to use in a welfare protocol as well as seeing if any of these parameters seem to effect to what extent calves are being taken by predators. Even if this mostly have to be seen as a pilot study as it is only conducted on one farm and with a limited budget, another objective was to see to what extent secondary effects of predatory stress effects the health of cattle. As very few assessed animals had lost calves to predators within the last year, it is hard to draw any conclusions regarding the latter objective. Therefore, the main focus of the discussion will be the methods used and how the welfare protocol can be enhanced and used in further studies on the subject. The following chapter will describe the parameters used for health assessment and if they are valid, reliable/repeatable and feasible.

### Welfare protocol and parameters

#### ***Body condition score:***

This parameter was included in the protocol as it is important for welfare both as a factor for good health and good feeding. Widely recognized as an important welfare indicator it is according to Roche *et al.* (2009) not fully understood how it makes the animal feel. In addition, according to the authors it's a parameter sensitive to subjective assessment, risk of low reliability and changes connected to the stage of lactation. Cows lose body fat reserves postpartum for up to 100 days afterwards and this is connected to the increase in lactation. Because of this a BCS of 3 up to 3.5 is considered optimal at calving (Roche *et al.*, 2009).

In the study, a majority of cows were scored between thin and good condition (48% were scored as 2.5). Also 20 cows were considered to be thin while only 3 were scored as fat. So even though 34% of the cows were scored in good condition the conclusion must be that the cows in general are a bit too thin to be in ideal calving condition. However, it must be taken into account that the assessment was made in the end of the dry season. A study by Ezanno *et al.* (2003) found that season and stage of gestation/lactation were two of the factors most influencing on cattle BCS. Continuing the body condition scoring of the cows after they have given birth will reveal if this is a seasonal problem or if the farm has to try to change their management routines. However, this is a complex issue as the farm also have to take into consideration other aspects as soil fertility in different pastures, predation threat and what's practical for management of the farm. Comparing BCS results of Nelore between studies are hard since no standardization of classes exist. Scoring in different studies varies from 3-9 classes (Fernandes *et al.*, 2015).

Assessing the cows at the same stage of lactation is optimal for reducing the number of factors affecting the results (Edmonson *et al.*, 1989). The average score in the cows assessed at calf handling was 2.63 while the same number for cows assessed from horseback (different stages of lactation) was 3.02. This is interesting as it shows that cows at the farm have a reduced body condition after giving birth. Also, it might explain why a larger proportion of animals have been scored 2.5 on the farm after I left there, as they now only score animals at calf handling. The

average score made by the cowboys is 2.63, exactly the same score as I had during calf handling. Though it can't be forgotten that this is a welfare indicator with possible judgement subjectivity and the different scoring can also depend on who is making the scoring (Roche *et al.*, 2009). Reliability was high (as described in the results) during my own scoring as well as when the cowboys were tested during the evening sessions on cattle BCS and maternal behavior.

Except for evaluating the validity and reliability of this parameter it's also interesting to see how the cows that had been exposed to predators scored and how the parameter relates to other parameters. The 10 cows that had lost calves to predators within the last year were scored between 2 and 3.5 with a curve that follows the curve for the rest of the animals (figure 7). With this number of animals exposed to predators I cannot draw any conclusions regarding the impact that long term predatory stress has on body condition if any. As more data is received from the farm in the future it will be easier to draw conclusions regarding what factors affect the body condition and if predatory stress is one of them. The question then will become if the reliability is still high when the scoring is done by the cowboys, which will depend on how motivated and thorough they are. Other studies have shown that body condition may decline in presence of predators (Kreeger *et al.*, 2002, White *et al.*, 2011) due to decreased forage intake and stress. But the question is if it can increase after a cow loses her calf and doesn't need to spend energy on feeding and guarding it.

### **Maternal behaviour score:**

This is a behaviour parameter and a type of animal-human response test. According to Hoppe *et al.* (2008) maternal protection is essential for calf development and survival. Heritability of maternal protective behaviour has been shown in multiple studies. High fear response and avoidance behaviour towards human has shown connection to increased calf/lamb mortality rates in both cattle and sheep. On the other hand, calf handling is necessary at management procedures as for example ear-marking. Protective cows can show aggression (especially when reared on pasture) towards the handler which might cause injuries both to animals and humans (Hoppe *et al.*, 2009).

This parameter was seen as important for this study as it might show if cows with history of predator attacks react different towards threats after that. Also, it is interesting to see if maternal protection affects to what extent the calves are being attacked. The results of this study showed that at this farm a large majority of cows reacted protective but without aggression towards the cowboys. 85% of the animals was scored in group 2 and this will be discussed later in the paragraph about potential improvements of the study. No cows showed complete ignorance or tried to escape even though a few didn't follow their calf all the way to the handling booth.

When comparing the cows that had lost calves to predators to the others no significant difference could be seen. The majority (88%) of the cow that had lost calves was protective without aggression while one cow attacked the cowboys. Of all the cows 10% showed some sort of aggression (group 3 and 4), which is about the same as the cows exposed to predatory stress. Perhaps more data received from the farm in the future can clarify if this behavior is affected by long term predatory stress.

When reliability was tested, by letting the cowboys score videos of maternal protection behavior, it was high. Furthermore, it's also interesting to know to what degree this parameter is influenced by other factors. For example, a study by Stehulová *et al.* (2013) indicated that male calves and calves with low birth weight get more protection by their mothers. This study also revealed that cows in good body condition provided more and more intense maternal protection for their calves which was beneficial for their growth. In my study, it's hard to draw conclusion about the relationship between BCS and MBS as such a large number of cows were scored in group 2.

### ***Swellings and lesions:***

As described in the literature review these parameters can mainly be used to identify management factors that affect the health of the animals. Recording the placement of the lesion/swelling is crucial for this purpose. The results of this study show that the farm has a problem mainly with swelling (19 recorded while only 6 recorded lesions). Of these swellings 84% were located on the neck exactly on the site for vaccine injection. The rest were detected on the back limbs. The lesions on the other hand were located on the head (50%) and on the back limbs (50%). No further recording of swellings and lesions were done by the farm as the workload for the cowboy would be too heavy if all parameters were to be recorded for every animal. Instead they record if some animals are treated for medical reasons.

None of the cows that had lost calves to predators had any lesions or swelling so no connection could be seen between eventual long term predatory stress and these parameters. Instead it has to be assumed that the largest proportion of the recordings has to do with injections to the neck. According to Cresswell *et al.* (2017) intramuscular injection of vaccines and antibiotics can cause trauma, abscesses and scars. Trauma from injections can be seen up to 12 months after injection and cause inflammation and infection. Even though it's mostly seen as an economical problem rather than a welfare problem due to loss of meat. To avoid injection site reactions recommendations are to use as aseptic procedures as possible (rarely done in large herds) and spread the amount injected in different locations if possible (Cresswell *et al.*, 2017).

### ***Lameness, cleanliness, respiratory disease and other diseases:***

As written in the results these parameters have been bundled together as they were not frequently recorded at this farm. No animals that had been exposed to predatory stress showed any reduction in any of these health parameters either. Therefore, no recordings were made from the farm after the study was concluded. As described in the literature review these are also parameters that mainly a problem in housed beef and indicate some sort of management/surrounding complications (Fregonesi *et al.*, 2007, AssureWel, 2017).

A Danish study concluded that access to pasture was the single most important factor for reducing the number of dirty animals as cows prefer to lay in clean and dry areas if given the possibility (Nielsen *et al.*, 2011). The authors also determined that bedding material, stage of lactation and age of the cow might affect the level of cleanliness. My study was done in the end of the dry season and obviously weather can affect cleanliness as well. Studies have shown high

inter-observer reliability regarding this parameter (80-90% agreement rates) (Winckler *et al.*, 2003). This is important as it shows that assessment will likely be repeatable.

Also concerning lameness as a parameter studies have found high inter-observer reliability (68-98% agreement on a 5-point scale)(Winckler & Willen, 2001). It is possible that the level of lameness might be affected seasonally as intake of amount of protein and carbohydrates will vary due to changed fertility of the soil. Heat-stress and increased intake of carbohydrates has shown amplified levels of claw horn lesions and lameness in cattle on pasture (Cook & Nordlund, 2009).

It is interesting that almost no other diseases or animals in need of further care was noted. This can indicate a good level of health at the farm and also that all feasible health parameters that can be studied from a distance was used in this study. The recording made regarding other diseases was mainly possible signs of mastitis. If more detailed examination should be done this would have to include milking the cow which is not practical and very time-consuming during calf handling. At one point during the study a cow had to be milked in order to feed an abandoned calf, but this took at least 20 minutes.

### **Effects of predatory stress**

It is clear that the farm Fazenda Real Sao Bento has a problem with predators and in particular jaguars. The farm lost 65 calves last year to predators, which constitutes around 1.9% of total cattle holdings (pers comm., 2017). The question is if this is a representative farm for Brazil and the Pantanal area. Other studies by Zimmermann *et al.* (2005) and Cavalcanti *et al.* (2010) found the mean number of cattle killed by predators to be between 2.1 – 2.3% of total cattle holdings, with absolute numbers ranging from 0-80 attacks per year. The farm Fazenda Real Sao Bento is located next to a nature reserve with a river running through it. Also, there are many small areas of woodland within the paddocks that allows the jaguars to stalk and get close to their prey. This type of environment is a good hunting habitat for the jaguar (Cavalcanti, 2008).

The farm was chosen for the reason that the cattle-predator conflict is very present which makes it easier to study. Though, this is important to remember when extracting the results from this farm and comparing it to others in for example other countries. Are the animals here more stressed because of the constant presence of predators? A study by Cooke *et al.* (2017) concluded that cattle exposed multiple times to predators showed more physiological changes associated with post-traumatic stress disorder than cattle that had never before been exposed to predators. This could indicate that cows living in close proximity of predators could have impaired welfare. Also, are there other stressors at this farm that are more important to the animals' health, for example access to water and food?

It's been established that predation is a significant problem on this farm. The question then is if this study showed any signs that long term stress from these attacks reduces the health of the animals. The quick answer would be no. No signs have been found that indicate that the animals that has lost calves within the last year have decreased health. Their body condition, behavior towards the cowboys and other health parameters were similar to that of the rest of the cattle.



This however doesn't mean that stress from predator attacks doesn't affect the health of animals. Firstly, as discussed earlier only 10 of the 388 animals assessed had lost calves to predators. This number isn't enough to draw any conclusions from regarding the matter of health effects from stress.

Secondly as described by Sejian *et al.* (2011) no welfare protocol can give a full assessment of an animals' health. Parameters were chosen as they are practical and feasible to assess in a large number of animals, but many health parameters cannot be examined in this way. Also, it's important to remember that not all stress has to give visible health effects (Jensen, 1996). To examine the long-term stress, it would be necessary to look at physiological markers like cortisol levels. Sheriff *et al.* (2011) claims that the cortisol sampling method needs to be determined depending of the nature of the study and if it examines acute or chronic stress. Many different sampling methods are available but in free moving herds as little handling as possible is desirable as described by Möstl & Palme (2002). The authors of this study found that faecal sampling is a preferable method, but also that cortisol levels were only elevated for about a week after the stressful event. This leads to another question, how long after the attack is the animal affected? 6 of the 10 cows assessed here were evaluated after they had given birth again, which means that they lost their last calf at least 9 months ago.

Another essential question to study is whether the condition of the cow or the calf is more important for the chances of an attack happening. Statistics received from the farm shows that more male calves were predated than females last year. Of the young calves (calves found without earmarking) 5 females were killed by jaguars compared to the 16 males that were killed. In the older calves (calves found with an earmarking) no gender difference could be seen as 22 males and 22 females were killed by predators. A study by Mathisen *et al.* (2003) claims that male reindeer calves stray further from their mothers, are more active and also more vulnerable to predation than females. This indicates that calf gender is an important factor for risk of predation. These results of gender differences according to Mathisen *et al.* (2003) weren't visible until the calves were 6 months old. This differs from the statistics received from Fazenda Real Sao Bento.

## **Discussion of the study**

The main objective with this study was to create a welfare protocol to assess the effects of predatory stress and I feel that this has been accomplished. This protocol is also usable in other countries and farms when further studies on this area are conducted. The AssureWel welfare protocol is designed for all beef cattle systems (AssureWel, 2017), and the additional maternal behavior score is usable whenever human interaction with the calves is present.

Some parameters assessed in this study didn't show much results, but there is still a point of keeping them in the protocol as they are feasible and valid to check. For example, respiratory disease and lameness was almost absent at this farm but still might be more common in other farms where cattle are housed indoors at times. This is because these diseases are more common in housed beef cattle (Hernandez-Mendo *et al.*, 2007, AssureWel, 2017). The parameters that

showed most variations during my study are body condition and maternal behavior score, which therefore were the parameters chosen for the farm to keep records of.

Even though I'm content with the study and the results, there are still a few unanswered questions and possible sources of error. First and foremost, I have discovered that it's hard to distinguish what is a possibility factor and what is a consequence when it comes to the parameters assessed in this study. Also, it's hard to exactly define what animals have been exposed to predatory stress and how long they are affected by it. According to Boonstra (2013) different animals react differently to predatory stress depending on what is profitable for their survival, and consequently this source of error is hard to get rid of. Studies have shown that prey animals express substances in the brain connected to stress and PTSD when exposed to predators visually or by odor (Campos *et al.*, 2013, Dielenberg, 2001). This indicates that not only the mother of the killed calf will be affected by the attack, but also other animals in the proximity.

It was hard to draw conclusions from the maternal behavior score as many animals were scored in the same group. The scoring system was proposed by our collages at São Paulo State University and mostly worked very well. I would though propose some sort of change to the scores so that the cows in group 2 are split up into two different groups. Some cows stay close to their calf the whole time, while others keep their distance but eventually follow the calf through the gate. Splitting this group into two groups could make the data easier to evaluate. The body condition score showed good reliability, but it must not be forgotten that this is a subjective parameter and sometimes it was hard to choose between two scores. Therefore, as also concluded by Roche *et al.* (2009) it is advantageously if the assessor is skilled and routinely uses this kind of measurements.

Even though the cows were found to be slightly thin postpartum the level of general health was good. This is supported by the fact that they claimed to have very few treatments and statistics show a low grade of mortality except from predators. Choosing a representative group of animals for the study is also very important. By looking at the cows postpartum and assessing only Nelore some confounding factors were eliminated. On the other hand, some animals were assessed from the horseback and these assessments has more factors that might disturb the results. For example, it's harder to assess animals that stays in the middle of the herd.

### **Future studies on the subject**

More studies are needed on the subject of secondary effects from predatory stress. The main question for future studies on the subject is according to me: what is an affect and what is a factor that decides which cow loses her calf? For example, if a cow is in bad body condition after she has lost a calf to a predator. Did she then lose her calf because she was in bad condition or has the stress made her weak afterwards? Also, it would be interesting to assess the calves to see what influence their health has on the risk of being attacked by a predator.

The farm used for this study will continue collecting data of cow body condition and maternal behavior. My suggestion would be to primarily study what health-factors on a cow contribute to the possibility of their calf being taken by a predator. The farm will also assess the horns of

the cows which can be used in this kind of study. When this has been answered more studies can be made on the health consequences. Following cows for a longer period of time would be very interesting. Also, some analysis of cortisol-levels could be made to see to what degree the cows are stressed after an attack and for what period of time.

Further long term investigations can be made regarding what other parameters affect the chances of an attack happening. Is it the cows body condition and behavior that has the largest affect? Or is it the calves condition, gender and behavior? For example, how far from the cow it stays or how much it vocalizes when being captured by the cowboys. There are so many interesting discussions and future studies to be made on the subject so hopefully this study will contribute to someone picking up where I now leave of.

## **CONCLUSION**

This study has found that measuring animal welfare, with focus on health-effects after predator attacks, is possible. Parameters used were BCS (Body Condition Score), MBS (Maternal Behaviour Score), swellings, lesions, lameness, cleanliness, respiratory disease and “other diseases”. The protocol is easy to use, valid, feasible, repeatable and can be used in other countries as well. Furthermore, the cowboys on the farm used for the study were taught how to score body condition and maternal behaviour of the cows to continue supplying data for future studies on the subject.

240 cows were assessed whereof 10 had lost calves to predators within the last year. In this study, no results indicated that the cows that had lost calves to predators had a lower level of health or changed maternal behaviour compared to the other cows at the farm. A conclusion that can be drawn from the study is that the cows at the farm generally are too thin after giving birth. Postpartum the mean body condition score was 2.63 while the rest of the animals in varying stages of lactation and gestation had a mean score of 3.02. Studies have shown that an optimal body condition for cows when giving birth is between 3-3.5 (Roche et al., 2009).

During this study no conclusion could be drawn regarding what is an effect of predatory stress and what is a factor contributing to the chances of an attack happening. For that question to be answered cows needs to be studied for a longer period of time, which hopefully can be achieved now that the farm is keeping records of welfare parameters. Also, cortisol-levels needs to be recorded in order to determine which animals are stressed and for what period of time. Finally, studies on what factors of the calves increases their chances of survival would be interesting to see.

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## Appendix A

AssureWel's welfare protocol that were used as foundation for the protocol used in this study. Added parameters were maternal behaviour score and calf number.

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